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The Role for an International Measurement & Verification Standard in Reducing Pollution

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ABSTRACT

The burning of fossil fuels is the primary source of emissions that result in climate change, acid rain and a host of other effects that damage human health, property and the environment. Estimates of the resulting costs range up to hundreds of billions of dollars per year globally. Energy efficiency and renewable energy investments reduce the burning of fossil fuels and, in turn, result in substantial health, property and environmental benefits. However, these benefits of efficiency and renewable energy investments have generally not been recognized. Lack of recognition of these benefits constitutes a significant market failure that has resulted in under-investment in energy efficiency and renewable energy technologies.

The failure to include the costs/benefits of emissions has distorted price and market signals, and has resulted in a misallocation of energy investments and prevented a more rational and cost-effective energy investment strategy around the world. This paper gives a brief introduction to the role that an international, consistent methodology can play in achieving and documenting emissions reductions from projects that reduce energy consumption and in helping to allow more rational and cost effective energy investment decisions. Potentially the most damaging for the environmental and health threats resulting from energy use is global warming, and particular attention is therefore paid to addressing this global challenge.

INTRODUCTION

The Intergovernmental Panel of Climate Change in its 1995 report states that "the balance of evidence suggests that there is a discernible human influence on global climate" (IPCC 1995). The 1997 Kyoto conference on climate change committed industrialized nations to reduce or sharply limit growth in greenhouse gas emissions and provided for investments in developing nations to limit the growth in these emissions. Emissions trading is a central feature of limiting greenhouse gas (GHG) emissions as envisioned in the Kyoto treaty. A standardized protocol can also provide a higher level of confidence to financiers of the projects and helps in reducing transaction costs—a major barrier in implementing cross-country and cross-sector projects.

The International Performance Measurement and Verification Protocol (IPMVP) provides a framework for calculating energy reductions before (baseline) and after the implementation of projects. It also provides a framework for developing an internationally consistent approach for estimating the contribution of efficiency investments to reducing a range of pollutants that result from the burning of fossil fuels. The four options with varying cost and duration and frequency of measurement requirements provide an flexible and broad framework that can be applied to a variety of energy efficiency measures in the commercial and industrial sectors.

The absence of a consensus, technically sound, consensus measurement and verification (M&V) methodology makes it difficult for the policymakers to arrive at a climate change trading regime even in the face of overwhelming evidence supporting the phenomenon of global warming and climate change. The most important of these treaties—

the Kyoto protocol - established emission targets for Annex I (industrialized) countries relative to their 1990 emissions levels.

The Kyoto Protocol provides four approaches to reducing emissions that will require effective and reliable performance measurement and verification (US Department of Energy 1998). Specifically, these are:

1) Domestic emissions trading programs;
2) Trading between the industrialized nations of Annex I (e.g. between the UK and Russia);
3) Project specific emissions crediting through *Joint Implementation* or *JI* between Annex I parties (e.g. for France and the Czech Republic); and
4) Project specific emission crediting through the *Clean Development Mechanism* or *CDM* for Annex I nations and non-Annex I (developing countries) such as the U.S. and Mexico.

International efforts to slow and then reduce greenhouse gas emissions are expected to be achieved through climate change trading programs within and between countries that will involve establishment of internationally agreed on rules on what counts as an accepted emissions reduction. The establishment of a successful international climate change trading program will require the common application of a standard approach to measure and verify emissions reductions. This paper describes the need for a consistent methodology and proposes a methodology that is being developed by the International Performance Measurement and Verification Protocol (IPMVP) process[1].

WHAT IS EMISSIONS TRADING?

Emission trading programs are based on the concept that emissions reductions anywhere within a specific area - ranging from a city such as smog-afflicted Los Angeles to worldwide global warming - can serve as the basis for an emissions compliance and trading program. It is an innovative regulatory concept that is based on providing economic incentives for industrial, and other facilities in order to reduce the pollutants and improve environmental quality. This market-based approach helps achieve a higher level of environmental compliance at lowered cost than traditional regulations. Emissions trading rewards firms that reduce emissions below a regulatory limit with emissions "currency", whether credits or allowances, generally measured in tons of emissions avoided. Reductions can be realized through investments such as energy-efficiency, renewable energy, fuel switching, and pollution control equipment. From these reductions, revenue can be generated through the sale of credits/allowances to firms that need emissions reductions in order to comply with regulatory requirements. The ability to measure and capture, through the use of "emissions currency," emissions reduction value (including health and environmental) is an important step in allowing the market to reward investments in energy-efficiency and renewable energy.

Existing trading programs have measurably reduced emissions at a fraction of the cost of command and control regulatory alternatives. For example, sulfur dioxide allowance trading is viewed as the most cost-effective approach for many U.S. firms to abate acid rain with prices starting at approx. $300/ton in 1993. Emissions trading has exceeded expectations, with traded prices at $200 per ton in early 1999[2].

Based upon the success of existing emissions trading programs, the Kyoto Protocol embraces trading as a cost-effective method of meeting emissions targets and timetables, and the overall objectives of the 1992 *United Nation's Framework Convention on Climate Change* (FCCC). Emissions trading, either within or between countries, allows those countries with high marginal abatement costs to buy emissions from countries with lower marginal abatement costs. Emissions trading, when applied in the global arena, can help countries with lower compliance cost to opt for

[1]This document includes extensive passages drawn from the draft description of the estimate tables developed for IPMVP, and is intended to provide an elaboration and broader explanation of purpose of this specific effort. IPMVP is a voluntary, consensus process established in 1992, involving more than 25 organizations and 100 individuals for developing consensus Measurement & Verification (M&V) approaches in the field of energy efficiency and renewable energy.
[2] See EPA acid rain website at www.epa.gov/acidrain/ats/prices.html.

an emissions level below their binding targets and sell the emission credit that is accrued to another country whose compliance costs are higher.

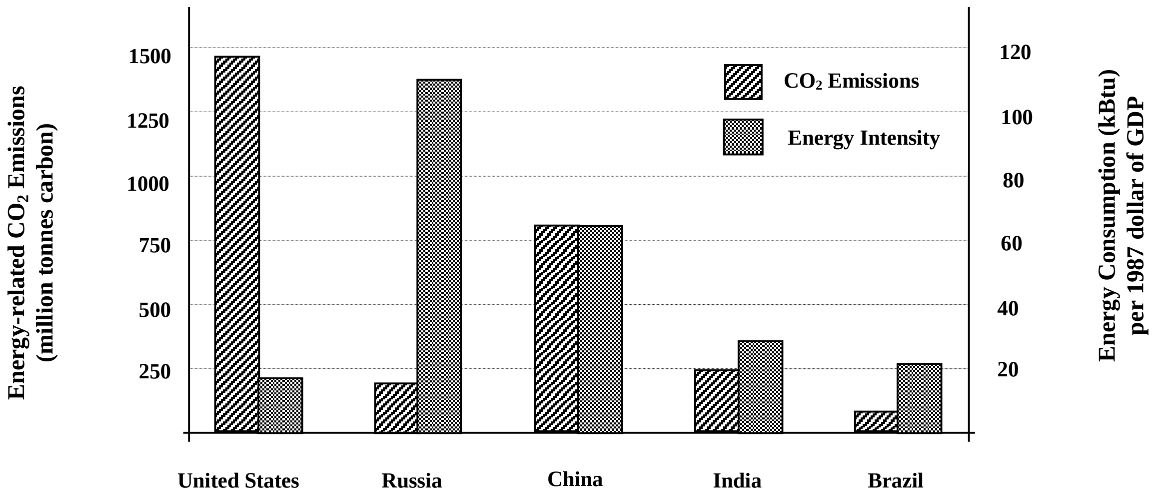

Figure 1: CO_2 Emissions and Energy Intensity for Five Nations

Figure 1 clearly shows that although the United States is by far the largest emitter of energy related carbon dioxide, it also has a relatively low energy intensity 16,800 Btu/1987$ (US Department of Energy 1999). This makes it expensive to reduce a ton of carbon dioxide in the United States as compared to say, in China, where the energy intensity is 62,700 Btu/1987$. This indicates that the emissions trading program can reduce the overall compliance costs and work to the advantage of both trading partners.

NEED AND ROLE OF PROTOCOLS

For a trading program to work, a ton of carbon in Beijing must be the same as a ton in Buenos Aires or in Baltimore. Buyers of carbon reductions in one country will need to have confidence that the tons they buy are calculated in a way that is reliable, consistent and transparent. Mere institution of a standard approach to measure and verify emissions reductions from energy efficiency measures won’t be enough to create a successful emission trading market. Additionally, quantifying other means of reducing greenhouse gas emissions such as carbon sequestration will be equally important.

Although the Kyoto protocol makes provision for emissions trading involving industrialized nations, rules for trading have not been established. The *Conference of the Parties* (supreme body of the UN FCCC) is required to establish principles, rules and guidelines for trading at a future date. The time is ripe for putting in place an M&V protocol that can be used as the common technical basis for documenting energy savings and awarding emissions credits. Some of the activities that can be covered by M&V protocols are:

- Industrial process upgrades;
- Motors, pumps or air-compressor upgrades;
- Boiler, chiller, lighting upgrades, Energy Management Control Systems etc.
- Energy efficiency measures that also reduce peak demand at facilities.

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- Switching to cleaner fuels.

In a report prepared by Resources for the Future, Lile et al. write that the Kyoto Protocol “provides no guidance on how these cooperative activities for GHG reduction and sustainable development would be undertaken in practice, including the particularly important issue of the relationship of the private sector vis-à-vis government institutions in designing, financing, and securing approval for jointly implemented GHG abatement projects.” They further point out that huge transaction costs pose great risks to a project implemented under JI or CDM framework, implying the need for a standardized approach to reduce risks and cut transaction costs (Lile et. al. 1998).

Measurement and verification of emissions reductions is a complicated task that cuts across many sectors, including energy efficiency in buildings and industry, agriculture, forestry, transportation and renewable energy. Fortunately, the international community, with participation from twenty countries, has already developed a measurement and verification methodology, the International Performance Measurement and Verification Protocol (IPMVP) for verifying and measuring energy efficiency savings as well as measurement and verification issues in renewable energy (www.ipmvp.org). Developed initially to measure and verify energy savings promised in Energy Savings Performance Contracts (ESPCs) and provide a greater level of confidence to financiers of the energy efficiency projects, the IPMVP also serves as a strong basis for determining emissions reductions from the energy efficiency and renewable sectors.

Its application can help cut transaction costs and increase consistency and reliability in determining emissions credits. The challenge of determining actual emissions reductions resulting from investments that reduce pollution, such as energy efficiency, is substantial. The IPMVP is intended to provide a useful tool to meet this challenge by offering a standard, industry consensus approach to measure and verify energy use and changes in use. Application of this protocol can provide increased confidence in the measurement of actual energy savings, and therefore provide greater confidence in determining associated reductions in emissions.

Guidelines have recently been developed by the Lawrence Berkeley National Laboratory for the U.S. Environmental Protection Agency that addresses the monitoring, evaluation, reporting, verification, and certification (MERVC) of energy-efficiency projects for climate change mitigation (Vine et al. 1999). These guidelines cover a range of issues, including:

- A description of seven methods for evaluating energy savings;
- An explanation of key issues influencing the establishment of a credible baseline (free riders) and the calculation of gross energy savings (positive project spillover and market transformation);
- A process for verifying and certifying project impacts, based on an interpretation of the Kyoto Protocol
- A discussion of the importance and value of including environmental and socioeconomic impacts in the evaluation of energy-efficiency projects
- Reporting forms; and
- Quality assurance guidelines that require evaluators and verifiers to indicate specifically how key methodological issues are addressed.

The LBL study determined that the IPMVP is the preferred approach for monitoring and evaluating energy-efficiency projects for individual buildings and for groups of buildings because it covers many of the key issues in monitoring and evaluation and because it allows for flexibility by providing several measurement and verification

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methods. The report concludes by recommending the national and international adoption of the IPMVP as a model for developing official MERVC-type guidelines[3].

Such a guideline is needed for the Joint Implementation (JI) and Clean Development Mechanism (CDM) projects – provisions made under the Kyoto protocol, in order to accurately determine their impact on greenhouse gases (GHG) and other attributes. IPMVP can be used to help quantify emissions credits, resulting from energy efficiency measures (EEMs) in the building sector and selected EEMs in the industrial sector. Together, these two categories cover approximately 50% of the total anthropogenic greenhouse gas emissions. IPMVP is not designed for and is not easily applicable to projects relating to electric utility sector (generation, transmission and distribution), improvements in the transportation sector, and forestry activities such as afforestation and reforestation.

INTERNATIONAL PERFORMANCE MEASUREMENT & VERIFICATION PROTOCOL

Higher confidence levels in energy savings performance levels translate into higher confidence levels for the emissions reductions associated with the resulting reduction in burning of fossil fuels. This is important for establishing a common basis for estimating reductions in emissions associated with energy efficiency gains. In the short term, the U. S. Environmental Protection Agency (EPA) is seeking to include energy efficiency as one creditable strategy for reducing emissions in their NO_x Budget Trading Program. (EPA, 1999). States affected by the SIP call (State Implementation Plan) will have the option to include energy efficiency projects as a way to comply with state NO_x reduction targets. This is a big step forward in the thinking at EPA, and offers potentially large financials savings and other benefits. For example, if an average of 5% of compliance were achieved through efficiency, this would save consumers an estimated $5 billion by 2003, cut compliance cost by $150 million and create 40,000 new jobs[4]. The Agency is looking to the IPMVP as the logical source of measurement protocols for energy efficiency. One useful tool that the IPMVP seeks to provide to EPA is a consensus approach for estimating confidence levels for emissions reductions.

The intent behind developing a saving estimates table is to provide a common international approach for estimating the energy savings from efficiency investments as a function of how these investments were made, especially with respect to the level of measurement and verification or commissioning involved. This can help in further accreditation of greenhouse gas emission reductions from energy efficiency. The approach discussed here is still under development and reflects one of several possible applications of the IPMVP in providing a consistent methodology for calculating emissions reductions that result from efficiency investments.

Accurate measurement gives building owners and managers valuable feedback to the operation of their facility which allows them to adjust building management to deliver higher levels of energy savings, greater persistence of savings and reduced variability of savings. A growing body of data shows that better measurement and verification results in significantly higher levels of savings, greater persistence of savings over time and lower variability of savings (Kats et al. 1997, Haberl et al. 1998). Greater persistence and lower variability, in turn, can form the technical basis for rewarding energy efficiency projects, which employ superior M&V techniques to determine energy savings by applying a lower discount factor for awarding emissions credits.

A study of 60 groups of energy efficiency upgrade projects found that whole building upgrades with strong M&V practices achieved substantially higher savings than projects with little M&V (Kats et al. 1997). Logically this makes sense, since real time measurement at multiple measurement points provides a strong diagnostic tool for building managers that allow them to better understand, monitor and adjust energy systems to increase and maintain savings. This finding is consistent with the experience of the US Federal Energy Management Programs[5] and reflect

[3] Personal communication with Ed Vine, LBNL March, 1999
[4] Linking Market Transformation with Air Quality, a presentation by Anna Garcia, U.S. EPA, March 2, 1999.
[5] Personal communications with Steve Kromer, LBNL (December 1998) and Brad Gustafson, LBNL (January 1999)

the very extensive long term metering work done at the Texas A&M University Loan Star program (Claridge et al. 1996).

To claim emission credits based on measured energy savings, one should take into account the following factors:

- Uncertainties and risks associated with EEMs
- Persistence of predicted energy savings
- Uncertainties in determining energy savings

Emissions crediting and trading programs for greenhouse gases as well as domestic trading programs, such as NO_X compliance in the USA, require estimates and discounts on credits from efficiency programs. The need for *Table 1* stems from the recognition that savings from energy and emissions are uncertain. The likely energy and emissions reductions depend in large part on the quality of upgrades, including how projects are measured and verified (both the extent and duration of the M&V). Better measurement and verification in whole building retrofits, for example, generally result in higher and more persistent savings over time. Since the type of M&V techniques deployed to monitor energy use is very much dependent on the load and operating hour profile of particular energy efficiency measures. These elements are separated out in the table below. The following table provides a proposed framework for determining fractions of credits (equal to 100% of projected energy savings – a discount) to be awarded to efficiency projects as a function of how those projects are implemented and measured.

Table 1: Proposed Fraction of Emissions to be Credited from Energy Efficiency Projects Using IPMVP Measurement Options

Options	Load	Operating Hours	Single Point Snapshot Measurement	Multi-Point Snapshot Measurement	Multi-point with short-term Continuous Measurement	Multi-point with long-term Continuous Measurement	Utility Bill Analysis	Hourly Data
A (System or Building)	Constant	Constant	0.9	-	-	-	-	-
	Constant	Variable but predictable	0.6	-	0.9	-	-	-
B (System)	Constant	Constant	0.9	-	-	-	-	-
	Variable but predictable	Variable but predictable	0.6	0.8	0.9	1.0	-	-
C (Building)	Variable but predictable	Variable but predictable	-	-	-	-	0.8	1.0
D (System or Building)	Variable but predictable	Variable but predictable	0.6	0.8	0.9	1.0	-	-

We use rows A in *Table 1* to illustrate how we arrived at the proposed fractions. Assume a lighting retrofit (first row), constant load, constant schedule, measured accurately soon after the retrofit. Because there is no long-term measurement, we assume that the savings will decay, so we propose only 90% credit. Now, assume a variable speed motor retrofit (second row), with a variable but predictable load and operating hours. There is now an inaccuracy in converting a short-term measurement into an annual predicted saving over time. So, even if there is long-term

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measurement to insure good maintenance, we propose only 90%. If there is no continuing measurement, we anticipate poor persistence, and drop the credit to 60%.

The fractions in *Table 1* are only estimates and will be only approximately right. Nonetheless, this is more precise and more useful format than anything else available. These estimates recognize the higher level of savings associated with good measurement and verification practices. By providing a single, simple approach to estimating associated energy savings and associated emissions reductions, this effort is intended to help generate a growing stream of financial rewards for efficiency projects from the value of emissions reduced.

Please note that estimate level here means best estimates for expected savings levels for a portfolio of projects. Individual project performance will vary, with some project achieving savings less than, and some more than, these estimates indicate. Overall, these estimates are conservative; that is we expect that the across a portfolio of projects , average energy savings achieved is expected to be equal to or higher than the estimates indicated here. Estimation of energy savings are based on two important factors:

- Variability in loads
- Variability in operating conditions

If both the loads and the operating conditions are constant, Option A with a single point snapshot measurement would be able to predict energy savings with greater precision. On the other hand, if both the loads and operating conditions are of varying nature, one needs to perform multiple point and/or continuous measurement at a system level or building level (hourly data collection) to reduce the uncertainty factor introduced by variability in loads and operating conditions. It is important to define the various terms that are frequently used in the measurement and verification of energy efficiency measures. The definitions for these terms are compiled from technical publications (EPRI 1996, US Department of Energy 1997).

Constant load applications by definition do not change their characteristics (loads or energy use per unit time) over time, so one time spot measurement (snapshot) is generally sufficient to obtain an estimate of equipment performance and efficiency.

Variable load applications change their characteristics (i.e. loads) over time. Therefore depending on the complexity of the measure, one can calculate component performance and efficiency under different sets of conditions, by moving from single point snapshot measurement (simple and inexpensive) to multiple point continuous measurement (more complex and expensive).

Constant operating hours is a 24 hour constant load or a regular, automatically switched load. It can be estimated by performing either utility bill analysis or short-term continuous measurements (one day).

Variable operating hours constitute a load that is for varying hours during the day, such as lights in an office building that are switched on or off by the occupants. Such operating hours can easily be tracked with a run-time logger.

Snapshot measurements are one-time or instantaneous direct measurements of a performance variable

Operating hours measurement records equipment or system run-time over a specific monitoring period.

Short-term continuous measurement involves real-time interval monitoring of a specific end use or technology over a relatively short time period (less than a month) that is long enough to capture all operational characteristics.

Long-term continuous measurement involves detailed monitoring of energy performance variables over a long time period (for the duration of the ESPC).

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Table 2: Revised Description of IPMVP Option A – D.

M&V Options[6]	Basis of Savings Calculations	Initial Cost[7] [8]	Annual Operating Cost[9]
Option A: Focuses on physical inspection of equipment to determine whether installation and operation are to specification. Performance factors are either stipulated (based on standards or nameplate data) or measured. ▪ Key performance factors (e.g., Lighting wattage or "motor" efficiency) are measured on a snapshot or short-term basis. ▪ Operational factors (e.g., Lighting operating hours or motor runtime) are stipulated based on analysis of historical data or spot/short-term measurements.	Engineering calculations or computer simulations based on metered data and stipulated operational data.	0.5 to 3%	0.1 to 0.5%
Option B: ▪ Intended for individual ECMs (retrofit isolation) with a variable load profile ▪ Both performance and operational factors are measured on a short-term continuous basis taken throughout the term of the contract at the equipment or system level.	Engineering calculations after performing a statistical analysis of metered data.	2 to 8%	0.5 to 3%
Option C: ▪ Intended for whole-building M&V where energy systems are interactive (e.g. efficient lighting system reduces cooling loads) rendering measurement of individual ECMs inaccurate. ▪ Performance factors are determined at the whole-building or facility level with continuous measurements. ▪ Operational factors are derived from hourly measurements and/or historical utility meter (electricity or gas) or sub-metered data.	Engineering calculations based on a statistical analysis of whole-building data using techniques from simple comparison to multivariate (hourly or monthly) regression analysis.	0.5 to 3% (utility bill analysis) 2 to 8% (hourly data)	0.5 to 3%
Option D: ▪ Typically employed for verification of saving in new construction and in comprehensive retrofits involving multiple measures at a single facility where pre-retrofit data may not exist. ▪ In new construction, performance and operational factors are modeled based on design specification of new, existing and/or code complying components and/or systems. ▪ Measurements should be used to confirm simulation inputs and calibrate the models.	Calibrated energy simulation/ modeling of facility components and/or the whole facility; calibrated with utility bills and/or end-use metering data collected after project completion.	2 to 8%	0.5 to 3%

[6] The cost of minimum M&V, in projects not following IPMVP involves an initial cost of 0.5% and an annual operating cost of 0.1% to 0.2% of the project cost.
[7] The initial M&V cost includes installation and commissioning of meters.
[8] In new construction, this is the % of the difference in cost between baseline equipment and upgraded/more efficient equipment
[9] Annual operating cost includes reporting, datalogger and meter maintenance cost over the period of the contract

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Table 2 lists the four IPMVP options for measuring and verifying baseline conditions and energy savings for the duration of the ESPC along with the first and annual cost for M&V related activities. These options can be used for either calculating individual technology or “facility-level” energy savings. These procedures are consistent, which means that for similar technology, the results can be replicated.

CONCLUSIONS

Energy-efficiency improvements are explicitly recognized within the Framework Convention on Climate Change (FCCC) as the low or no-cost “no-regrets” measures of first choice for parties seeking to reduce emissions. Therefore, the emissions trading and crediting systems being developed under the FCCC present a tremendous opportunity for cost-effective energy-efficiency project and reinforce the need for the International Performance Measurement and Verification Protocol. Similar performance-based monitoring, reporting and verification efforts are being developed in the land use sector. Project development, involving emissions reductions are underway in anticipation of the emissions trading and crediting provisions of the Kyoto Protocol becoming operational.

International efforts to respond to the threat of climate change have also increased the need for industry consensus approaches to measuring and verifying the economic and environmental benefits of investments in efficient or lower emission energy choices. The IPMVP can help project developers and policy makers to develop rigorous, common, fair and cost-effective emissions trading systems to abate greenhouse gas emissions.

ACKNOWLEDGEMENT

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